

# Identification and Quantification of Nitrate Transport in Agricultural Area

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# Korea Environment Institute

## Purpose

- Research and development of environmental policies and technology
- Professional assessment of environmental impact statements
- Contribution to the prevention and resolution of environmental problems

## Established in Dec. 1992

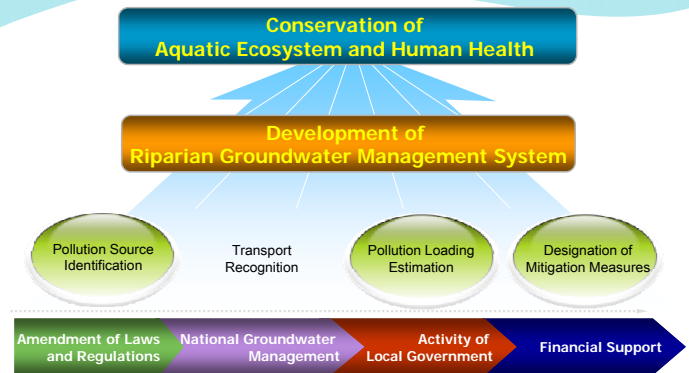
## Organization



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# Objectives

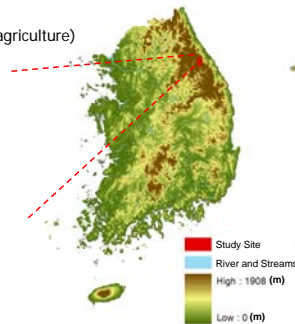
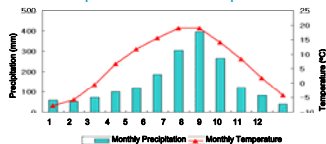


# Study Site

## Characteristics

- Location: DoAm Watershed in Pyeongchang, Gangwon-do (DoAm Dam was constructed in 1990)
- Area: 149.2 km<sup>2</sup>
- Landuse
  - Agriculture: 12.0% (typical highland agriculture)
  - Pasture: 11.0%
  - Forest: 72.0%
  - Urban: 3.0%
  - Water: 2.0%

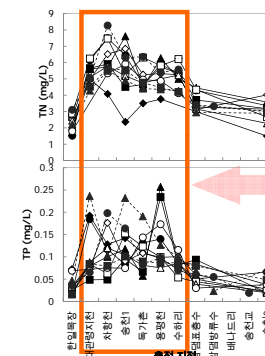
## Temperature and Precipitation



# Study Site

## Characteristics

- Water Quality in Lake and Stream



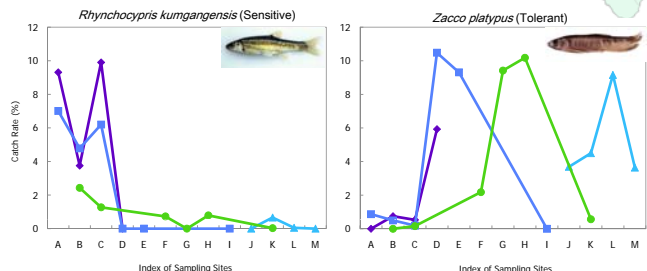
## Study Site

<Sampling Sites>



### Characteristics

- Aquatic Ecosystem in Lake and Stream
- Different Species in upstream and downstream of agricultural area. (D is located at agricultural area.)



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## Study Site

### Major Issues in the DoAm Watershed

#### Eutrophication



#### Civil Complaints

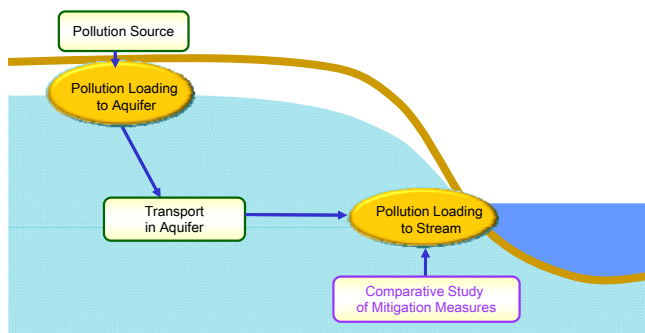


**들뜯수로 생계위협 일하들 주변 주민 사위**  
 2006-11-14 [12:12]  
 울고대며 들뜯을 주변 어민 20여명은 14일 안동시 일하면 한국수자원공사 일하들관리단 청문회에서 들뜯수로 인한 이득자본 고통을 호소하며 문제를 해결해 달라며 피해보상을 요구하는 상이 시위를 열었다. 이들은 '한국수자원공사 죽어 지난 2002년과 2003년 들뜯을 투사로 애미 들뜯을 으로 유출된 들뜯을 가를 대하 들뜯을로 부출을 하지 않 이 고기가 죽는 등 이득자본이 감소. 장계를 위협받고 있 다.'며 '1시간 들뜯을 1인당 1인당 1인당 한끼 보상에 야 한다.'고 주장했다. 이들은 또 피해 보상과 함께 들뜯 관리부위로 들뜯을 유입했다에 이에 대한 규명도 요구했다.  
 이에 대해 한국수자원공사 관계자는 '이는 자연재해로 행정보상 근거가 있어 보상을 수 없다.'며 '들뜯을 정어 시합과 함께 1인당 위로금 30만원씩 지급할 계획을 갖고 있다.'고 말했다. [매일신문 2006-11-14 [12:12]]

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## Nitrate Transport

### Transport from Source to Sink



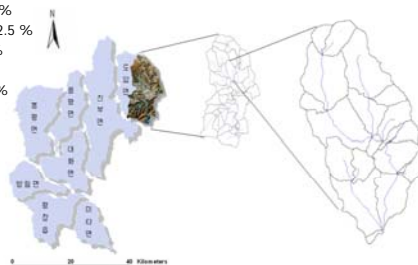
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## Nitrate Transport

### Pollution Source (Fertilizer Use)

#### Downscaling for Data Collection

- HeongGae-Ri
  - Area: 4.59 km<sup>2</sup>
  - Landuse
    - Forest: 96.1 %
    - Agriculture: 2.5 %
    - Water: 0.9 %
    - Urban: 0.2 %
    - Pasture: 0.3 %

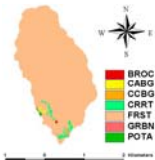


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## Nitrate Transport

### Pollution Source (Fertilizer Use)

#### Data Collection



Month	Potato	Carrot	Cabbage	Broccoli	Napa Cabbage	Bean
3						
4	↓					
5						
6		↓				
7			↓			
8				↓		
9					↓	

Crops		Amount of applied fertilizer	Fertilizer Ingredient (N-P <sub>2</sub> O <sub>5</sub> -K <sub>2</sub> O)
Potato (kg/ha)	Compost	12,000	15-18-12
	N	150	Compost
	P	180	(200Sack/1000pyeong)
Carrot (kg/ha)	Compost	1,200	6-9-6-7-9-1500
	N	80	Compost
	P	98	(200Sack/1000pyeong)
Cabbage (kg/ha)	Compost	12,000	5-6.5-4.3-1500
	N	50	Compost
	P	65	(200Sack/1000pyeong)
Broccoli (kg/ha)	Compost	12,000	8-7.1-4.5-1500
	N	80	Compost
	P	71	(200Sack/1000pyeong)
Napa Cabbage (kg/ha)	Compost	12,000	T-C=32
	N	20	T-N=2.0
	P	34.9	P2O5=3.49 K2O=0.96 MgO=0.67 C/N=16
Bean (kg/ha)	Compost	6,000	12-9-9
	N	40	Compost
	P	75	(200Sack/1000pyeong)

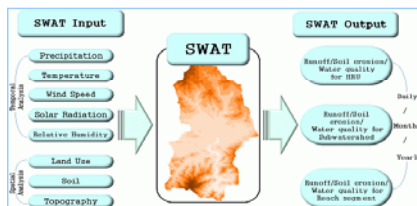
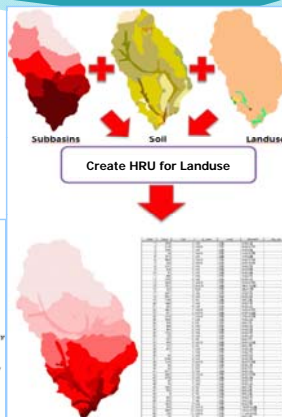
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## Nitrate Transport

### Pollution Loading to Aquifer

#### SWAT (Soil and Water Assessment Tool)

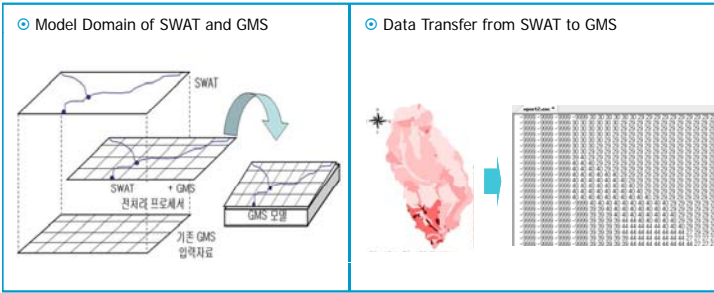
- Unit: Hydrologic Response Unit
- Strength: Simulation for Landuse
- Weakness: Limitation to show pollutant transport in aquifer



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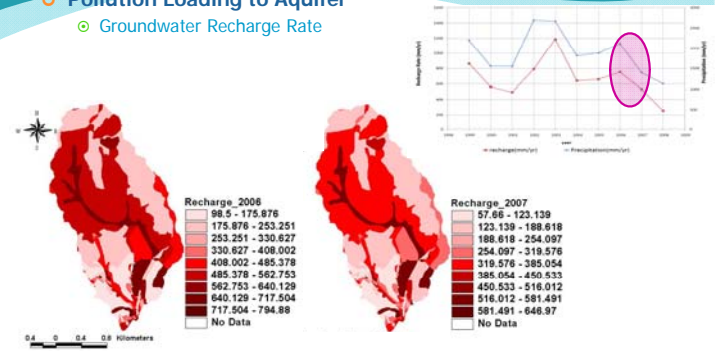
# Nitrate Transport

- Pollution Loading to Aquifer
  - Linkage between SWAT and GMS
  - A GIS-based interface was developed to transfer data from SWAT to GMS.



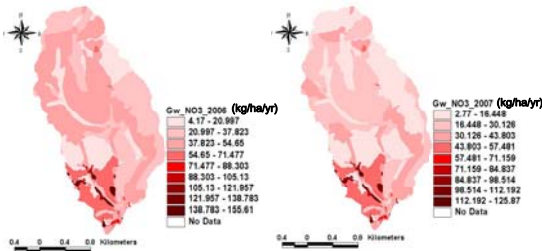
# Nitrate Transport

- Pollution Loading to Aquifer
  - Groundwater Recharge Rate



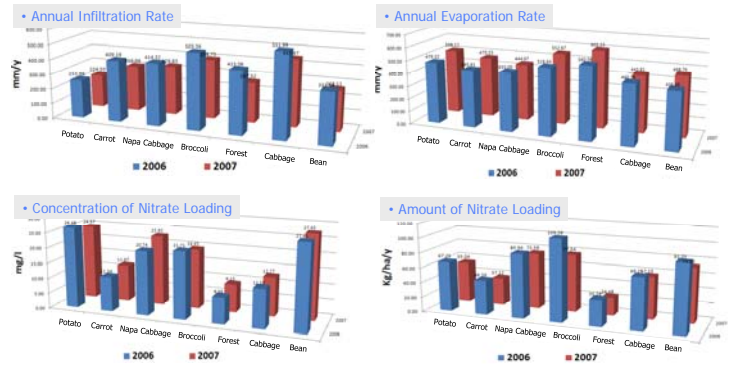
# Nitrate Transport

- Pollution Loading to Aquifer
  - Nitrate Loading to Aquifer



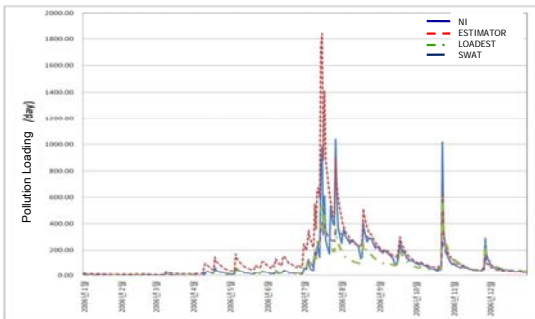
# Nitrate Transport

- Pollution Loading to Aquifer
  - Estimation by Year and Landuse



# Nitrate Transport

- Pollution Loading to Stream
  - Comparative Study of Pollution Loading (1)
  - Estimation methods



# Nitrate Transport

- Pollution Loading to Stream
  - Comparative Study of Pollution Loading (2)
  - Sampling frequency

	NI	ESTIMATOR	LOADEST	SWAT Estimation
Daily Sampling	33,084.2	50,439.2	25,925.3	30,080.5
Weekly Sampling	34,481.9	66,315.8	31,357.4	30,080.5

# Nitrate Transport

## Pollution Loading to Stream

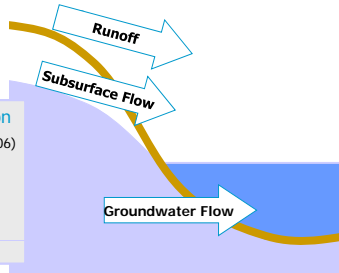
### Separation of Pollution Loading by Runoff and Groundwater

- Estimation by SWAT
  - by Runoff
  - by Subsurface Flow
  - by Groundwater
- Estimation by GMS
  - by Groundwater

### Other Case Study of Separation

(Shin, 2006)

- Wolgok-Ri in Kangwon-do
- Nitrate Loading to Stream
  - by Baseflow: 53%
  - by Direct flow: 47%



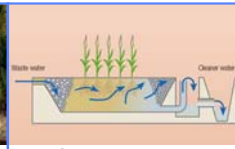
# Groundwater Management

## Mitigation Measures

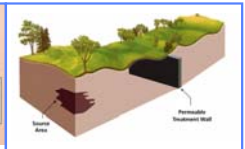
- Comparative Study
  - Characteristics
  - Performance
  - Removal Efficiency for Target Site
  - Suitability for Target Site



<Riparian Buffer Zone>  
Image adapted from Google Image



<Constructed Wetland>  
Image adapted from Google Image



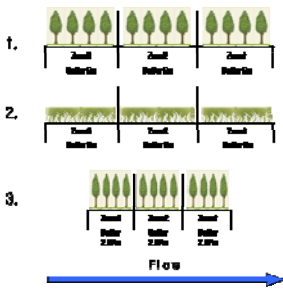
<Permeable Reaction Barrier>  
Image adapted from Google Image

# Groundwater Management

## Mitigation Measures

### Riparian Buffer Zone

- Scenarios Simulation



### Nitrate Removal Efficiency

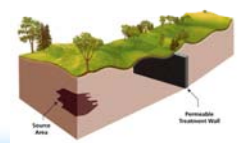
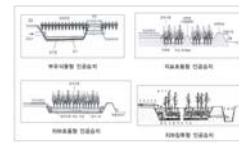
- Simulated by SWAT

	Runoff	Subsurface Flow
Scenario 1	27.98%	75.23%
Scenario 2	27.85%	4.26%
Scenario 3	24.51%	44.62%

# Groundwater Management

## Mitigation Measures

- Comparative Study
  - Pollutant Removal Efficiency
  - Suitability on Target Site



# Groundwater Management

## Development of Management Plan

### Amendment of Law and Regulations

- Riparian Groundwater Management
- Linkage between GW and SW

### National Groundwater Management

- National Groundwater Management Master Plan
- National Groundwater Monitoring Network

### Activity of Local Government

- Local Groundwater Management Plan
- Subsidiary Groundwater Monitoring Network

### Financial System

- Budget for Riparian Buffer Zone
- Special Accounting System

Korean Laws regarding Riparian Groundwater

법령	유한범 지하수 및 수생태계 관련 내용
제7조 2항 (유한범구역에서 지하수개발 및 이용허가)	유한범구역 내에서 지하수를 개발하는 경우 지하수 영향조사를 수행하고 이를 토대로 유한관리청과 협의해야 함
제12조 5항 (지하수 보충구역의 지정)	지하수의 지나친 사용으로 유한범의 마르는 현상이 발생하거나 발생의 우려가 있는 지역, 혹은 주변 생태계에 심각한 악영향을 미치거나 미칠 우려가 있는 지역에 대하여 지하수 보충구역 지정
11조 (생물 개발허가의 제한)	시도지사는 동법 제8조제3항에 의한 환경영향조사결과 다른 공공의 지하수개발의 개발 또는 지표수의 수질 등에 영향을 미칠 우려가 있다고 인정되면 생물 개발허가를 하지 않거나 1일 위수령을 제할 수 있음
제 50조 4항 6 호 (유한범의 사용 허가 등)	지하수의 채취량이 유한범량에 영향이 있다고 판단되는 경우 유한관리청은 사용료 징수 가능

# Thank you for your attention

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## Acknowledgement

This subject is supported by Korea Ministry of Environment as "The GAIA Project".

